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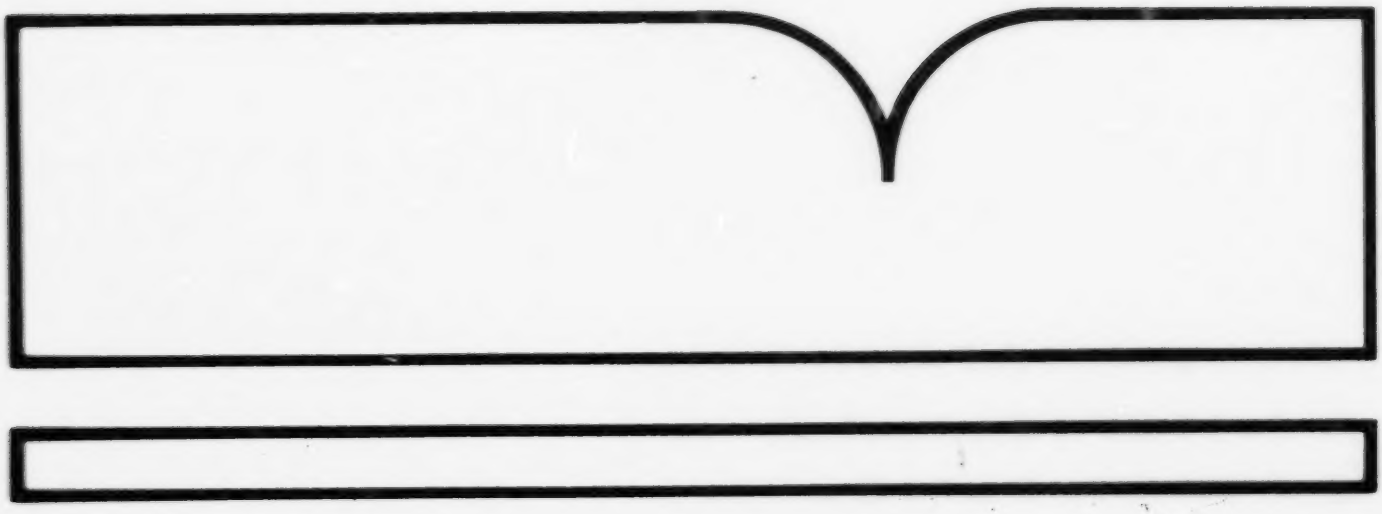

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VOLATILE ORGANIC CHEMICALS IN 10 PUBLIC-ACCESS BUILDINGS

by

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16. ABSTRACT

The U.S. EPA carried out studies of indoor air quality in 10 buildings. Qualitative analysis identified over 200 aromatics, halogens, esters, alcohols, phenols, ethers, ketones, aldehydes, and epoxides, in addition to several hundred aliphatic hydrocarbons. The total organic load for nine buildings exceeded outdoor levels, by factors of up to 100 for new buildings. New buildings had high levels of eight organics (e.g., decane, xylenes, 1,1,1-trichloroethane). Levels in three new buildings declined with half-lives of 2-8 weeks. For some chemicals (e.g., trichloroethylene) levels increased with time, indicating the influence of consumer products or activities.

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Abstract

The U.S. EPA carried out studies of indoor air quality in 10 buildings. Qualitative analysis identified over 200 aromatics, halogens, esters, alcohols, phenols, ethers, ketones, aldehydes, and epoxides, in addition to several hundred aliphatic hydrocarbons. The total organic load for nine buildings exceeded outdoor levels, by factors of up to 100 for new buildings. New buildings had high levels of eight organics (e.g., decane, xylenes, 1,1,1-trichloroethane). Levels in three new buildings declined with half-lives of 2-8 weeks. For some chemicals (e.g., trichloroethylene) levels increased with time, indicating the influence of consumer products or activities.

The U.S. EPA studied the air quality of 10 public-access buildings (offices, schools, homes for the elderly, and one hospital) in 1983-1985[1,2]. Three buildings were new, and were visited two or three times to determine chemicals that might be elevated and their rates of outgassing. Seven buildings were older and were visited once (three times in the case of the hospital) to determine typical levels. Target chemicals included 32 volatile organic compounds, of which about 20 were often detectable.

Most visits lasted 3 days, with 6 consecutive 12-hour air samples collected in triplicate at different volumes on Tenax cartridges at each of 3 indoor locations and 1 outdoor location (the air intake for the building). Samples were analyzed by GC/MS. Recoveries from 50 control cartridges spiked with 9 NBS standards ranged from 72(± 19)% for 1,1,1-trichloroethane to 95(± 35)% for ethylbenzene. Median relative standard deviations for approximately 250 triplicate samples ranged from 11% for para-dichlorobenzene to 22% for trichloroethylene.

Qualitative Identification of Organics

A total of 16 samples (12 indoor, 4 outdoor) from 4 buildings were chosen for full qualitative GC/MS scans. About 100-200 organic compounds were identified on each sample. Table 1 lists the families and numbers of compounds identified (excluding aliphatic hydrocarbons such as hexane, decane, etc., which numbered in the hundreds). The 24 most common compounds are listed in Table 2.

New Buildings

Three buildings were monitored within 1-6 weeks of their completion, and were then revisited, following occupancy, 2-4 months later. Table 3 shows

eight chemicals or groups of chemicals (including 3 aliphatic and 5 aromatic compounds) with dramatically elevated concentrations (up to 100 times outdoor levels) immediately following construction. These chemicals were identified in paints, adhesives, and other building materials. After 5-6 months outgassing, indoor concentrations were approaching outdoor concentrations, but were still elevated, for some of these chemicals. By contrast, chlorinated compounds were generally unaffected by aging of the building. One partial exception was 1,1,1-trichloroethane, which showed a steady decline with time at one of the 3 buildings. Another partial exception was trichloroethylene, which increased sharply with occupancy of the two office buildings, but not at the nursing home.

The initial concentration of the three straight-chain aliphatic hydrocarbons in the two office buildings was about 100 times the maximum outdoor concentrations in all cases. Calculated average half-lives for decane, undecane, and dodecane in these two buildings were 2.2, 4.0 and 4.8 weeks, respectively, corresponding to their decreasing volatility. Thus it would take roughly 3, 5, and 6 months, respectively, for these three chemicals to reduce to concentrations that are double the outdoor values. This supports the Scandinavian decision to require 100% outdoor air makeup for the first 6 months of a building's existence. Assuming exponential decay of the source, the observed concentrations of decane, undecane, and dodecane can be produced by the outgassing of about 0.2, 0.1, and 0.06 g/m^3, respectively, over the life of each building. In the case of one building (volume = 15,000 m^3), this would require about 5 kg of these three chemicals to outgas from the building materials.

Old Buildings

Seven occupied buildings ranging in age from 1 to 13 years were also analyzed for the same pollutants. Again six consecutive 12-hour samples were collected at 3 indoor locations and also outdoors near the building air intake. The mean indoor concentrations are displayed in Table 4, together with the median 3-day average outdoor concentration. Although all buildings have somewhat higher indoor than outdoor levels for most chemicals, indoor-outdoor differences are generally small compared to those observed in new buildings. Exceptions include elevated levels of trichloroethylene in one old office (corroborating the increased levels observed in the new office building following occupancy); p-dichlorobenzene in the hospital and homes for the elderly, perhaps due to its use as a room or toilet deodorant and disinfectant; 1,1,1-trichloroethane in several buildings, perhaps due to spray can use; and various aromatics, possibly due to painting, refinishing, or solvent use.

References

1. Sheldon, L.S., Handy, R.W., Hartwell, T.D., Whitmore, R.W., Zelon, H.S. and Pellizzari, E.D., Total Exposure Assessment Methodology (TEAM) Special Study: Indoor Air. Final Report, EPA Contract #68-02-3679, 1987.

2. Sheldon, L.S., *et al.*, Monitoring in Public-Access Buildings. Final Report, EPA Contract #68-02-4840, 1987.

TABLE 1. ORGANIC COMPOUNDS[a] FOUND IN FOUR BUILDINGS

	Number of Compounds	Number of Appearances
Aromatic Hydrocarbons	54	322
Alcohols	45	83
Ketones	39	73
Halogenated Hydrocarbons	20	143
Aldehydes	19	56
Esters	19	32
Ethers	10	13
Phenols	9	14
Epoxides	6	10
Nitrogen-Containing Compounds	6	10
Sulfur-Containing Compounds	5	7
Carboxylic Acids	4	14
TOTAL	236	777

[a]Excluding several hundred aliphatic hydrocarbons

TABLE 2. ORGANIC COMPOUNDS[a] FOUND MOST OFTEN IN FOUR BUILDINGS

	Number of Locations Compounds Present		
	Total	Indoor	Outdoor
Acetone	16	12	4
*Benzene	16	12	4
Toluene	16	12	4
Xylenes	16	12	4
*Styrene	16	12	4
Ethylbenzene	16	12	4
Ethylmethylbenzenes	16	12	4
Trimethylbenzenes	16	12	4
*Tetrachloroethylene	16	12	4
Naphthalene	15	12	3
Methylnaphthalenes	15	12	3
Dimethylethylbenzenes	15	11	4
*1,1,1-Trichloroethane	15	11	4
*Trichloroethylene	14	11	3
Propylmethylbenzene	14	10	4
*Dichlorobenzenes	14	10	4
Propylbenzene	13	11	2
Nonanal	13	10	3
Trichlorofluoromethane	12	9	3
Diethylbenzenes	12	8	4
*Methylene chloride	11	8	3
*Chloroform	10	7	3
Decanal	10	9	1
Acetic Acid	10	7	3

[a]Excluding aliphatic hydrocarbons

*Mutagenic or carcinogenic properties

TABLE 3. MEAN 3-DAY CONCENTRATIONS (ug/m^3) OF ORGANICS IN THREE NEW BUILDINGS

	Recently Constructed			Following Occupancy				
	Office 1	Office 2	Nursing Home	Office 1	Office 2	Office 1	Nursing Home	Maximum Outdoor Concentration
Number of Samples	20	18	18	19	18	20	18	6
Time Since Completion (weeks)	1	2	6	7	15	22	23	-
Aliphatics								
Decane	380	440	68	38	15	4	4	4
Undecane	170	210	69	48	34	13	4	2
Dodecane	47	150	31	19	24	5	NO	1
∝-Pinene	NM[a]	14	5	NM	25	NM	ND	ND
Aromatics								
Xylenes	214	59	33	27	19	12	7	6
Ethylbenzene	84	51	8	6	5	5	2	2
Trimethylbenzenes	NM	110	26	NM	13	NM	4	3
Ethyltoluenes	NM	36	16	NM	8	NM	3	2
Propylbenzenes	NM	9	5	NM	2	NM	1	ND
Benzene	5	3	2	7	5	7	2	5
Styrene	8	3	3	7	3	4	1	4
Chlorinated								
1,1,1-Trichloroethane	380	13	4	100	39	49	2	10
Trichloroethylene	1	ND[b]	3	38	8	27	1	1
Tetrachloroethylene	7	ND	1	2	2	3	1	1
Dichlorobenzenes	1	ND	2	1	3	1	1	ND
Chloroform	1	NM	NM	2	NM	18	NM	17
Carbon tetrachloride	1	NM	NM	1	NM	1	NM	1
1,2-Dichloroethane	NM	ND	ND	NM	5	NM	ND	ND

aNot measured
bNot detected

TABLE 4. MEAN 3-DAY CONCENTRATIONS (ug/m^3) OF ORGANICS IN SEVEN BUILDINGS

	Office	Office/ School	Nursing Home	Homes for Elderly No. 1	Homes for Elderly No. 2	School	Hospital	Median Outdoor Concentrations
Number of Samples	18	18	18	30	22	16	18	6
Aliphatics								
Decane	2	6	2	27	2	1	3	ND
Undecane	3	7	ND	23	2	1	2	ND
Dodecane	ND	2	ND	6	2	1	ND	ND
∝-Pinene	ND	3	ND	NM	NM	NM	ND	ND
Aromatics								
Xylenes	36	12	4	11	15	15	13	13
Ethylbenzene	10	3	1	3	4	4	3	4
Trimethylbenzenes	10	5	2	NM	NM	NM	2	1
Ethyltoluenes	8	3	1	NM	NM	NM	2	1
Propylbenzenes	2	1	ND	NM	NM	NM	ND	ND
Benzene	6	4	3	11	8	9	3	6
Styrene	2	1	1	2	1	2	1	1
Chlorinated								
1,1,1-Trichloroethane	41	11	3	23	15	23	16	5
Trichloroethylene	1	11	ND	1	1	1	ND	ND
Tetrachloroethylene	4	4	1	3	4	6	2	3
Dichlorobenzenes	1	ND	ND	4	1	2	7	ND
Chloroform	NM	NM	NM	2	2	ND	NM	1
Carbon tetrachloride	ND	ND	ND	1	2	1	ND	ND
1,2-Dichloroethane	ND	ND	ND	NM	NM	NM	2	ND

[a]Not measured
[b]Not detected